SFWMD Draft Response to Peer Review Comments of Dr. Merryl Alber, Ph.D. for the July 2002 Draft Loxahatchee River MFL Technical Documents

The following are initial *draft* peer review comments prepared by SFWMD staff. District staff are reviewing these comments and are in the process of supplying additional information requested by some panel members. As a result, some of these peer comments and District responses may change after consideration of supplemental information. Final peer review comments will be posted once they are received.

The following comments were submitted in support of the methods, approach, and documentation of the proposed MFL:

- *"…It is clear that the staff of the SFWMD has put a large amount of effort into the proposed MFL, and this is in many ways an improvement over the previous draft document. The report does an excellent job of addressing the comments provided in 2001, the literature review is improved, and the document is better organized. I think the shift away from cypress as an indicator is warranted, and the selected freshwater tree species provide a reasonable basis for discerning differences in the health of the floodplain community along the salinity gradient…"*

- *"…This [the literature review] is much improved over the previous version, in particular because there has been a clear effort to locate information on the salinity tolerances of cypress…"*

- *"… The results of the vegetation survey show a clear gradient in the distribution of the 6 chosen indicator species in the floodplain community, and, although there is not technical information in place on the salinity tolerances of the various trees over the course of their life cycles, it serves as a useful starting point for the identification of healthy, stressed, and significantly harmed locations along the Northwest Fork of the River. Although these are judgment calls, the selected locations are supported by the data in terms of observed changes in the presence of the various species and by their measured characteristics (e.g. as we move downstream, fewer VEC species are represented and those that are there are smaller, with fewer seedlings and saplings)…."*

- "…T*he Ds/Db ratio is extremely interesting and looks like a useful approach for summarizing salinity data. Perhaps it could be used to characterize field salinity observations (e.g. between 1997 and 2000)…."*

- "…I applaud the District's efforts to incorporate an adaptive management component in this effort. The proposed work on monitoring tributary/creek flows, the groundwater investigations, continued salinity monitoring and vegetation sampling should all provide useful information that can work to improve the MFL criteria…"

The following comments summarize Dr. Alber's concerns with the draft document

<u>Page 1, 2nd paragraph</u>: "*…There are some fundamental problems associated with the application and interpretation of the hydrodynamic model, and I do not think the document as it now stands adequately supports the proposed MFL….*"
<u>Page 2, 4th Paragraph</u>: *The salinity data presented in Appendix D were used to calibrate the hydrodynamic model, but the empirical relationships between salinity and flow were not used in any way in this document. I think these relationships are extremely useful (particularly those derived for current conditions, after the gaps had been closed) and might be appropriate as either a check on modeled salinity/flow relationships or as the basis for setting an MFL (see below). The original relationships, which were computed using Excel, are presented in figures D3-D6. These are very poor fits, and, in response to my comments on last year's document, they have been redone in SAS using variable flow-averaging periods (pages D11 – D22). The SAS fits are much improved over the ones done in Excel and could be very useful. Curiously, the SAS analysis is not referred to anywhere in the text, and SAS analyses were not performed for stations 66 and 67.*

- **<u>District Response</u>**: We agree with the reviewer's comment that the document needs to include a section in the Appendix that discusses the empirical relationships generated by Excel and SAS as presented in the report and how these relationships compare with the hydrodynamic model output (also see the following responses below).

<u>Page 3, 5th Paragraph</u>: *Although the 2-d model does an adequate job of matching long-term field salinity trends, the figures in Appendix E suggest some real discrepancies between observed and modeled salinity. This is acknowledged in Appendix P (p. P-4), where it states that salinity in the upper estuary is extremely sensitive to freshwater input and points out that the majority of the freshwater input was estimated from ratios (which are quite variable in reality but are fixed in the model). I understand new surface flow stations are addressing this, but without this information, and with another large estimate of inflow from groundwater (estimated as 40 cfs in a system where 35 cfs from the Dam is being proposed as the MFL), predicted salinities in the upper estuary are extremely suspect. The model may be a useful tool for exploring different management scenarios, but I am concerned about the over-reliance on model predictions of salinity as the basis of the proposed MFL*

- **<u>District Response</u>**: The reviewer was not supplied with color copies of the graphics presented in Appendix P and therefore it was not clear that (a) the model tended to follow the same pattern of daily salinity change as shown by the field data and (b) the model also tends to more closely predict field data at the more upstream sites where the vegetation communities of concern are located. Color copies of Appendix P have since been provided to Dr. Alber for review.

  District staff also looked at flow ratios calculated from measured data obtained from the Lainhart Dam and the other three tributaries under various average and low flow rainfall periods and compared these values to those used in the model. In general, the flow ratios used in the model were comparable to field measurements recorded during low rainfall periods, the period of time of most concern. For example, in the model the Lainhart Dam represents 44% of the total flow delivered to the NW Fork during the dry season as compared to inflows from the three other tributaries. Field measurements show this ratio to be 45% for data collected from the 1980-81 drought dry season, 46% from the 1980-81 drought wet season, 40% from the 1989-90 drought dry season, and 56% from the 1989-

90 drought wet season. Flow data is not available from Hobe Grove Ditch and Cypress Creek after 1994 as these gages were damaged after a major storm and were not replaced.

The estimate of groundwater flow was derived from a comparison of field data derived from a 1983 USGS report and measured flow/salinity data collected from a dry period in May 1999. The District recognizes that more groundwater data flow data would be desirable to confirm the estimate used in the model, but the 40 cfs value currently represents "best available data". We have no evidence to suggest that overall regional groundwater levels have changed within the basin since 1985, the period of time when the river was first designated as a Wild & Scenic River, to affect this rate.

The hydrodynamic/salinity model currently represents the District's best available tool for determining the complex interactions between daily tributary inflows and daily tidal fluctuations within the river, including variations resulting from the effects of lunar and solar cycles (e.g. spring or neap tides) and "lags" in the movement of salinity up/down the channel between tidal maxima.

Page 4, 1st Paragraph: *It is instructive to compare the flows/salinities predicted by the model with those derived from the analysis presented in Appendix D: according to the model, the flow required to maintain a high tide salinity of 2 at RM 8.6 is 54 cfs (obtained from Table 7 on p. E-18), whereas an average bottom salinity of 2 ppt is correlated with a flow of 64 cfs (p. D21). At RM 7.7, the model flow is 89 cfs (again to maintain a salinity of 2). This matches the Excel fit quite well, but the prediction from the SAS relationship is approximately 140 cfs (p. D18). This suggests that the model may underestimate the flow required to maintain salinities at their target levels and/or underestimate salinities at any point in the river, which would result in an inaccurate MFL. If the intent is to link flow and salinity it would be more defensible (and simpler) to stick with the empirical relationships derived in Appendix D.*

- **District Staff's Response**: The review has identified the need for District staff to conduct additional analysis that compare model results with available field data. These additional analysis are needed to give the reader greater assurance that the model results compare favorably with observed data, and that use of the hydrodynamic/salinity model represents the best tool available to establish flow/salinity relationships within the NW Fork of the river. To that end, District staff will conduct additional analysis and provide language in Appendix D and in the results section of the report that compare modeled data versus existing field information. This section of the document will also discuss the technical reasons and rationale as to why the District selected the hydrodynamic/salinity model as the best tool available for determining long-term flow salinity relationships.

  A review of the data presented in Appendix D noted a number of discrepancies between results provide by the SAS analysis and the results provided by the Excel analysis. For the reasons noted during the first peer review, we did not favor use of the Excel data. However, when we examined the data produced by SAS, we also noted some significant discrepancies. For example in the upper figure on page D-18, approximately 7 data points in the range from 100 to 150 cfs are above the SAS-predicted curve and more than 30 data points lie below this curve. This suggests (to us) that the SAS relationship may be over-predicting the amount of flow required for given level of salinity in this flow range. This was one of several reasons, we decided not to use either of the statistical relationships and use the model instead. That is why the new version of the document did not include reference to either statistical approaches. Again, we agree the document needs to provide a discussion comparing the empirical relationships presented in Appendix D as compared to the model output and why the model was chosen as the tool of choice for this analysis.

Page 4, 2nd Paragraph: *Even if the model were judged as the most appropriate tool for predicting salinity at different locations in the river under different flow conditions, it makes no sense to use a flow/salinity model calibrated with current data to predict 30 years worth of salinity. First, the document makes clear that there have been extensive changes in both the watershed and the estuary over that time period, such as dredging in the estuary, changes in land use resulting in changes in the amount of overland runoff and groundwater infiltration, and closing the "gaps" (which added 0.7 miles to the river). All of these changes could affect flow/salinity relationships, making historic salinity predictions based on current relationships less accurate. At the very least, some of the model predictions could be compared to historic salinity data (e.g. Appendix A describes studies by Chiu (1975), Hill (1977), Russell and McPherson (1974), and Law Environmental (1991), all of which collected salinity information).*

Page 4, 3rd Paragraph: *Second, even if it could be demonstrated that the model can in fact be used to predict historic salinities, flow conditions have changed over the 30-year time period: The G-92 structure was not constructed until 1974, its capacity was increased in 1986 and additional culverts and operational criteria were added in 1987. In fact, the document states that flow over the Lainhart Dam averaged 52 cfs from 1977-1989 and increased to 86 cfs from 1990-2001, and that the occurrence of flows below 35 cfs decreased from 34% of the time to 25% of the time between the two time periods. This means that salinities at given locations in the river were very possibly greater before 1987 than they are today (this could be verified by comparing some of the field observations). Moreover, the reference point chosen by the SFWMD as the basis for establishing an MFL is 1985. It therefore does not make sense to look back to 1970.*

All of the problems stated above mean that using a 30-year record to determine salinities (and deriving statistics about the average amount of time salinities at different sites are greater than a particular threshold) is not useful for understanding current conditions or setting MFLs. That said, the Ds/Db ratio is extremely interesting and looks like a useful approach for summarizing salinity data. Perhaps it could be used to characterize field salinity observations (e.g. between 1997 and 2000).

- **District Staff's Response**: Some of the information provided in the document suggests that watershed storage and drainage patterns have changed significantly within the basin over the past 30 years. It is true that over the past 10 years significantly more flow has been directed to the NW Fork via G-92 and the Lainhart Dam during normal and above normal rainfall conditions. This is due to increased rainfall experienced over the past 10 years as well as improvements made to G-92 which can now direct more water from the Loxahatchee Slough to the river (when it is available). However, our understanding of the watershed indicates that overall storage within the basin has remained unchanged since construction of C-18 in 1957-58. This means that during dry periods only a certain amount of water can be stored in the basin due to its limited water storage capacity. As a result, the amount of water directed towards the NW Fork during dry periods in the 1990s, is comparable to dry season flows that were recorded during the 1970s and 1980s which is precisely the problem that the MFL is trying to address. Because the basin has a limited water storage capacity, dry season flows delivered to the river have not changed significantly over time. Therefore, we believe it was reasonable to use current flow/salinity data relationships to predict past salinity events. **Table 1** provides a summary of these relationships based on flow/duration curves developed for Lainhart Dam data from different time periods. As shown in **Table 1** the amount of flow directed towards the river during high and normal rainfall periods (10th, 25th and 50th percentiles) has increased between 1985-1989 and 1990-2001, however the amount of water available for delivery to the river during low rainfall or drought periods (75th & 90th percentiles) has not increased much between 1985-1989 and the 1990-2001.

Table 1. Percent of time flows were equaled or exceeded at the Lainhart Dam

	Percent time of Lainhart Dam flows were equal to or exceeded (values reported in cfs)				
Period of record	10%	25%	50%	75%	90%
1971-2001 all data	173	105	60	29	14
1971-1984	120	90	51	25	14
1985 - 1989	116	90	59	31	16
1990-2001	226	152	82	35	14

* Data obtained from Flow duration curves

The primary purpose for developing a 30 year salinity history for the river was two fold. First it was necessary to provide a means for representing historical salinity conditions that have impacted the river over time. Secondly we needed a 30 year salinity record to capture the interannual variability of rainfall patterns that have occurred within the basin to help determine a return frequency for the occurrence of natural low flow periods that could be incorporated into the MFL criteria.

As you point out, we are implementing an adaptive assessment approach to our future research and monitoring efforts. Our ongoing flow/salinity monitoring program with the USGS has been enhanced through the placement of additional continuous flow and salinity monitoring stations. These additional data will help to address a number of the technical uncertainties associated with the model predictions. These new data should indicate the degree to which our proposed MFL will achieve the desired salinity conditions. If monitoring results show that the proposed flows are not sufficient, they will be subsequently modified as needed to protect the resource from significant harm. As stated in the our MFL Recovery Plan, a number of major projects are underway to provide more flow to the river – to achieve a sustained flow of 35 cfs or greater by 2006 and a flow of 65 cfs or greater by 2018.

Page 2, 2nd Paragraph: *The historical flow data is presented as a very long table in Appendix D, without comment. One concern I have is whether these data were all corrected, based on the recalibration that occurred recently (this goes for Tables 23 and 24 and Figure 20 in the text as well). Although I understand that flows at G-92 are correlated with those over the Dam, they're not the same, are they? If they are, this should be stated. If not, the document would benefit from a presentation similar to that in Figure 19 of flow over the Dam since that is what is being regulated. Table 24 and Figure 20 are useful, but it would be instructive to see some summary data (e.g. different percentile flows) for the period from the reference year (1985, if that is selected) to the present.*

- **District Staff's Response**: We have presented an analysis of the flow data from Lainhart Dam in Appendix H, but as you have pointed out, we have not included a discussion of source, re-calibration history, etc. In addition, we agree with the reviewer that a historical analysis and re-calibration history should be clearly presented in the main body of the report. We will also include a clear explanation of how G-92 and Lainhart Dam flows are linked together, but are not the same. This oversight will be corrected in the final draft of the technical document. The suggestion that a figure for Lainhart Dam flows, similar to Figure 19 for the G-92 structure, is well taken.

Page 1, 3rd Paragraph: *This [literature review section] is much improved over the previous version, in particular because there has been a clear effort to locate information on the salinity tolerances of cypress. However, the document would benefit from more information on the life history characteristics, functional roles, and salinity tolerances of the 6 chosen indicator species.*

- **District Staff's Response**: Comments noted.

Page 2, 1st Paragraph: *I'm not sure this is actually an application of the VEC approach. There is a complete list of resource functions and services provided in the document, but they are not tied very well to the floodplain swamp community. Instead, the trees that were identified are useful as indicators, rather than particularly "valued." The document indicates that these species were chosen because they occupy different ecological niches and have different functional roles, but this is not well documented. The species chosen are all relatively long-lived, and it seems like including some herbaceous species with shorter life spans is perhaps worth considering as they might provide faster response times and a better cross-section of the community.*

- **District Staff's Response**: The group of species identified as indicators collectively form part of a "valued ecosystem component", namely the freshwater forest canopy. These species are part of a multi-level high forest canopy that provides a specialized habitat upon which many species depend. A description of the function of this forest component can be found in Appendix C, page C-20. It is this group of six floodplain forest species that is the target VEC, rather than a single indicator species as is often the case. We can try to clarify that concept in the final draft of the document, as it may not be sufficiently clear as written in this section.

  Because we were trying to relate long-term salinity conditions to impacts to the freshwater community, long-lived species were selected. This reflects our commitment to determining the potential deleterious effects of chronic exposure that may not show up until long after the effects of acute exposure have passed. Available studies of shorter-lived species and short-term response times (acute exposure effects) are presented in the literature review section. However, the suggestion that there is value in also considering the response of shorter-lived species with faster response times is well taken and we are moving towards identifying those candidates through a contract with a consultant. We realize that understanding both the short term and long-term impacts of salinity exposure to the freshwater community are important. A discussion of short-term versus long-term exposure (i.e. chronic versus acute) can be found in Appendix C, page C-18. We can further address this issue in the final draft of the technical document.

Page 2, 3rd Paragraph: *The salinity data presented in the document are interesting. One suggestion is to recalculate the information in the Wild and Scenic segment of the river without station 63 to determine if average salinities have in fact increased over the past decade (as referred to on p. 102). This is an important point: elsewhere in the document the data suggest that flow has increased over the past decade and it would be very useful to know whether this change in flow has resulted in a measurable change in salinity or whether increased flow over the Dam has been offset by other changes in the watershed.*

- **<u>District Staff's Response</u>**: Comments noted; we will provide a description of the SAS analysis and show how these results compare to the modeled output.

<u>Page 2, 5th Paragraph</u>: *This was a straightforward, complete analysis of vegetation types in the estuary over time. However, I find it worrisome that no major changes in vegetation cover were observed between 1985 and 1995. The footnote in table B-4 indicates that vegetation in a segment of the river below Trapper Nelson's was estimated from 1995 photographs. Could this substitution have perhaps led to the erroneous conclusion that things did not change in this area? Given the improvements in G-92 and the resultant increase in flow that occurred in 1989, was there a concurrent decrease in salinity (as mentioned above)? If there were an increase in salinity, wouldn't we expect to see a downstream shift in the indicator community? Perhaps this is the explanation for the field observations reported on p. 132 that suggests the location of the stressed area has moved downstream between 1985 and 1995? This needs to be explored. If there has been increased flow and decreased salinity, which in turn has led to a shift in tree distribution, that would be good evidence that the indicators are in fact appropriate. It might also mean, however, that the choice of 1985 as a reference year would result in managing towards a situation with less freshwater inflow than occurs now. Finally, when evaluating shifts in vegetation it is worth keeping in mind that there are other factors that could account for changes in vegetation besides changes in hydrology.*

- **<u>District Staff's Response</u>**: The referenced footnote in Table B-4 should have read "…a segment of the river ***<u>upstream of</u>*** Trapper Nelson's were estimated…". As written, it could be confused with indicating an area downstream of Trapper Nelson's, which is not the case. Because the areas upstream of Trapper Nelson's have remained essentially unchanged from historical conditions (e.g. 1940 reference aerial photo), this estimate is not particularly relevant to documenting change on the NW Fork relative to salinity exposure. Hence, our comparison of 1985 and 1995 aerial photos remains complete for the areas of interest (i.e. the NW Fork downstream of Trapper Nelson's).

  It was noted although perhaps not clearly in this section of the document, that even though flows to the NW Fork have increased with the improvements to G-92, the duration of low flow events has not significantly changed (see Table 24). It is during these periods that potential damage to the freshwater community can result from salinity intrusion. So, even though flows have improved, the benefit is mostly during average and high flow times.

  The discrepancy between the location of the "stressed" area mentioned in the 1984 EIS and the District's vegetation survey in 2002 may be attributed to the fact that the location of the transition zone in the EIS was based upon qualitative, subjective, visual accounts. The location of the transition zone from "healthy" to "stressed" communities in the 2002 vegetation survey was founded on measured field data. Because the location of the beginning of the stressed zone in the EIS was not founded on measured field data, it is not possible to re-survey field sites for comparison of 1985 and 2002 time frames. Hence, comparison between the two remains more of a presentation of what is known to have been recorded in past documents with what has been found in current studies.

  In order to address the possibility that other factors may be involved in the observed changes in vegetation along the NW Fork, a discussion was included in Appendix C, page C-17.

<u>Page 3, 3rd Paragraph</u>: *The results of the vegetation survey show a clear gradient in the distribution of the 6 chosen indicator species in the floodplain community, and, although there is not technical information in place on the salinity tolerances of the various trees over the course of their life cycles, it serves as a useful starting point for the identification of healthy, stressed, and significantly harmed locations along the Northwest Fork of the River. Although these are judgment calls, the selected locations are supported by the data in terms of observed changes in the presence of the various species and by their measured characteristics (e.g. as we move downstream, fewer VEC species are represented and those that are there are smaller, with fewer seedlings and saplings). Given the fact that these trees used to occur further downstream, it is probable that salinity is an important factor that controls their distribution. One point to note is that the trends do not level off (e.g. as we move up to RM 10.6, trees are more abundant, larger, and have more seedlings and saplings). One wonders if another station further up-river would yield even more, in which case the selection of a representative healthy site might need to be re-visited.*

- **<u>District Staff's Response</u>**: The observation that some of the vegetation trends did not "level off" is noted. Above the Trapper Nelson site (approximately river mile 10.6), the river's character changes significantly. The river narrows substantially, becoming more stream-like, and is entirely covered by the forest canopy. Downstream of Trapper Nelson's, the channel widens and the river distinctly splits the forest canopy, resulting in a shoreline vegetation ecotone that is not found upstream. All vegetation surveys were conducted in this area. For this reason, a comparison of vegetation data from sites upstream of Trapper Nelson's with sites downstream of there would not be consistent or recommended.

<u>Page 3, 4th Paragraph</u>: *The observation that chloride shows a better gradient along the river than soil salinity is most likely due the fact that salinity has a much smaller dynamic range (it is constrained between 0 and 36). This makes it a less sensitive measurement, but I do not agree with the interpretation that this suggests salinity is not retained in the soil.*

- **<u>District Staff's Response</u>**: Comment noted.

<u>Page 4, 5th Paragraph</u>: *The MFL was chosen based on the model-predicted salinities at the locations identified in the vegetation surveys as healthy, stressed, and significantly harmed. To begin with, the goal of the MFL is not clear: if RM 9.2 has already been identified as an area that is experiencing significant harm (over what time frame?), then it makes no sense that the flow target has been chosen to prevent significant harm from occurring there (as stated on p. v and p. 149). The time frame is also not clear. On p. C-16 it suggests that long-term average salinity conditions since 1970 have led to the decline in freshwater vegetation, yet the analysis in Chapter 5 suggests that using those long-term averages is an appropriate basis for protecting the resource from further harm. Once the baseline condition gets sorted out (is it 1985? and has flow, salinity, or floodplain changed since that time?), this needs to be revisited.*

- **<u>District Staff's Response.</u>** Examination of historic aerial photography data indicated that hydrologic conditions from 1940 to 1985 has led to a decline in condition of the freshwater community, The condition of the resource in 1985 (when the river was designated as a Wild & Scenic River) was a reflection of this past salinity history. Changes that have occurred since that time have increased flow to the river during normal and high rainfall periods, but have not significantly improved these vegetation communities. We contend that improvements in these communities has not occurred because the river continues to experience periods of low or zero flow (see Table 1 above and Table 24 in the document) that are allowing salt water to penetrate upstream with about the same frequency as occurred historically, and that these events are preventing recovery. We are proposing, through the MFL, to greatly reduce the number of events that result in zero or low flow periods.

In addition, the goal of the MFL is to protect the identified resource from significant harm. The salinity regime identified at river mile 10.2 appears to support a healthy freshwater floodplain swamp, so that regime was applied as the maximum allowable salinity at river mile 9.2 where there still exists a remnant freshwater swamp. Hence, the proposed MFL not only protects the remaining intact community found at river mile 10.2, but also allows some recovery of remnant freshwater communities upstream of river mile 9.2.

<u>Page 5, 2nd Paragraph</u>: *If current vegetation at RM 10.2 is deemed healthy and the MFL goal is to protect it from harm, then what is required is to provide as much flow to RM 10.2 as it currently gets (i.e. the status quo). If this is the case, it would be much more straightforward to analyze the flow record over an appropriate period (e.g. since 1985, or perhaps since G-92 was improved or since the gaps were closed) and determine average flow (or a particular percentile flow, or the proportion of time that flow falls below a particular percentile). Interestingly, the report states that average flow over the Dam was 70 cfs from 1971-2001 (p. 160). In comparison, the model results presented in Table 40 suggest that 50 cfs is required to maintain average historic salinities of <0.15 at RM 10.2 This again suggests that the model is underestimating flow.*

- **<u>District Staff's Response</u>**: Average flows recorded for the river shown in Table 23 includes periods of high flow (> 1,000 cfs) as well as long periods of low or zero flow. The latter are of special concern. Under current conditions, an average flow of 70 cfs may include periods of zero flow and may not protect the resource, whereas a lower average flow of 50 cfs, with a minimum flow of not less than 35 cfs, for 20 days duration, occurring no more often than once every 6 years would better protect the resource against salt water intrusion (significant harm).
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<u>Page 5, 3rd Paragraph</u>: *If the MFL goal is to provide enough freshwater so that the salinity regime currently experienced at RM 10.2 can be reproduced at a downstream location (e.g. RM 9.7 or 9.2), then it becomes necessary to understand the relationship between flow and salinity, and this is where the model comes in. However, even if the model was appropriate and could be used to predict salinities at these river locations, I find the logic here extremely convoluted. What is essentially happening is that a) the model begins with a relationship between salinity and flow, b) historic flow data are used to predict historic salinity, c) historic salinity data are used to determine Ds and Db, d) Ds and Db are related back to flow, when all that is really needed is the relationship between salinity and flow.*

- **<u>District Staff's Response</u>**: The goal of the MFL is to protect the resource from significant harm and providing sufficient freshwater flow is one means of doing so. In addition to understanding the relationship between flow and salinity, it is also important to understand the relationship between salinity and harm to the resource. Because of a lack of suitable long-term salinity data for multiple sites along the NW Fork, a model was used to generate a long-term salinity daily time series that would provide reasonable estimates of the long-term salinity history at upstream locations. Ds and Db, a summary of this generated salinity time series, was used to relate changes to freshwater vegetation (the identified resource to be protected) with salinity. This analysis was carried out by request of the 2001 Peer Review Panel's recommendations.

Page 5, 4th Paragraph: *Moreover, when I followed the data in order to do a "reality check" on the model, things did not add up: Table 24 reports that flows of less than 35 cfs at the occurred 25% of the time at the Lainhart Dam between 1990 and 2001, and 35% of the time between 1971 and 1989 (for an average event duration of 15 or 24 d with a return frequency of approximately 2 mo). In Table 37 the model predicts that a flow of 35 cfs will result in a salinity of 2 ppt at RM 9.2 (the basis of the proposed MFL standard), and in Tables 35 and 36 we see that model-predicted salinities of 2 ppt occurred on average for 46 d every 6.8 mo., or 18% of the time at RM 9.2. I recognize that there is a response time built into the model and that we cannot expect a 1:1 correlation between flow and salinity, but these estimates of Ds (46 d), Db (6.8 mo), and % time over the threshold (18%) are very different than the flow observations (15-24 d, 2 mo, and 25-35%, respectively). Likewise, flows of 10 cfs occurred 7% of the time in the data presented for the dam (an average of 19 d every 9 mo). However, at 10 cfs the model predicts a salinity of 2 ppt at RM 10.2, which is estimated to have occurred only 1% of the time (an average of 22 d every 6 y, which is also used in the proposed MFL). Either I've misinterpreted these results or the model does a very poor job of estimating these parameters and should not be used to select an MFL.*

- **District Staff's Response**: Your questions and concerns have required the District to take a much closer look at the details of how modeled data (daily and long-term modeling results) compare with actual measured salinity data during the calibration and verification periods. We were aware of potential discrepancies between the measured data and modeled data but felt, on the whole, that the model was providing a reasonable picture of long-term flow/salinity conditions in the river. Furthermore, because the actual record of measured data was so sporadic in time and location, use of the model was preferred, since it could be used to generate a continuous picture of conditions in the river at any desired location over a 30 years period.

  Our first step in this analysis was to look at salinity conditions for water quality station #66 as represented in Figure 21 on page E-42 in the appendices. This graphic provides a comparison between modeled versus actual measured salinity conditions in the river from May to June 1999 (at the end of the dry season) at water quality station #66, which is located at river mile 9.4, within the area that has experienced "significant harm" based on our vegetation analysis.

  Actual flow data from Lainhart Dam for May to June 1999 are provided in the table on page D-52, column 3. Flow across Lainhart Dam during this period was at or below 10 cfs during most of the month of May and the first four days of June. Flow then increased rapidly to 135 cfs by June 13 and remained high for the rest of the month. Actual salinity data (red line on Figure 21 in Appendix E) were measured sporadically during this period. Salinities were in the range from 5-7 ppt during the early part of the month but then declined from May 10 (about 240 hrs) to May 25 (600 hrs), at which point there is a break in the record. The period from 840 to 930 hours represents the period from June 4 to June 12. During this time, measured bottom salinities decline from 5 ppt to zero within one day while the modeled salinity data show a steady decline to zero over a four day period. Figure 21 also shows the long-term salinity record (solid dark line) indicating a lag time of about four days and then a decline to zero over about a period of about 5 days.

Daily salinity values produced by the model showed variations in that generally reflect freshwater flow from Lainhart Dam along with solar/lunar tidal cycles etc. Predicted salinities at station # 66 during the low-flow period in May and early June ranged from a minimum low tide low salinity of about 1 ppt (near 600 hours) to a maximum high tide high salinity of about 13 ppt (at about 48 hours).

By contrast, results of the long-term model, agrees with the almost constant discharge from the Lainhart Dam, showing a 33 day period from about 75 hours to about 900 hours when salinities were above 5 ppt. The long term model shows a 4-5 day lag when salinity conditions change in the system, which is a function of how this aspect of the model works (see the note on page E-16)

Another comparison between modeled and measured data is provided by examining the salinity vs. discharge relationship graph in Figure D-6 on page D-7 for station #66 and looking at the extreme left hand side of this graph at the distribution of salinity values for flows of zero to 5 cfs. Under these low flow conditions, salinities ranged from 0.5 to about 9.8 ppt. Without doing a formal calculation, we counted approximately 11 data points above 5 ppt and 23 or so in the range from 2 to 5 ppt. It appears as though the median salinity for zero discharge is somewhere between 4 and 5 ppt.

Overall, results of these comparisons indicate that, in the short-term, the salinity model provides estimates of salinity that are within the same range as field measurements. Differences appear to occur when some undocumented input of freshwater (such as local rainfall) is occurring that results in a lower than estimated salinity value. Such an event may have occurred between 300 and 600 hours (Figure 21, page E-42). The long-term model, which estimates a daily average and does not specifically account for lunar and solar cycles (see page E-16 and graphic example in Figure 19), but does include their values implicitly in determining an overall long-term average salinity regime. The long-term model has a smoothing effect on the data. In the example shown in Figure 21, at very low flows, the result was "constant" estimated salinity of about 5-6 ppt that is very close to the median of observed data, which was on the order of 4-5 ppt.

A more variable data record, at station 65 (river mile 8.6) is shown in Figure 20 on page E-4. This graph indicates that there are periods when the long term model appears to overestimate the salinity (e.g. 2800 to 4000 hours) and periods when it underestimates (1200 to 2400 hours). It should be noted that the "actual" salinity record during the period from 1600 to 1700 hours, ranging from 10 to 16 ppt, may be in error due equipment malfunction or transcription errors. Examination of actual flow data from the month of March (page D-52, second column) indicates that flows throughout that month were generally in the range from 30 to 50 cfs, with the exception of a four day period from March 5-8 when flows declined to 25 cfs.

If we look at the SAS relationship on page D-21 (upper graph) a flow of 25 cfs could be expected to produce a bottom salinity of about 7.5 ppt , with a range, from 0 to 13 ppt. By looking at Figure 19, we can see that this time period corresponds to a neap tide, and so the short-term model predicts a relatively lower salinity value (due to weaker tides), on the order of 1-2 ppt (on Figure 20) and the long-term model predicts a salinity in the range of 3 ppt.

The consensus based on this type of analysis was that the calibration and verification in 1999 were relatively good. However, it was apparent that each of the approaches has distinct limitations and potential sources of error or bias. The decision to use the model, as opposed to using either of the statistical relationships was based on a) the model could be used to provide a continuous set of daily, weekly, monthly values over a designated time period, that provided some consideration of known forces, such as tides, that influence salinity conditions; b) The model provided us with a better ability to interpolate and extrapolate to locations throughout the river, beyond the model boundaries and existing data sets, and in areas where available data were very limited (e.g. station 67) or non-existent; and c) the model provided a better basis for comparison of current conditions with hypothetical future conditions.

Based on consideration of how the model analyzes and interprets flow data, and the apparent discrepancies between field-measured salinities and flow across Lainhart Dam (as evidenced for example in the amount of "scatter" that exists in the graphs on pages D-6 and D-7 and pages D-15 to D-22), it is not surprising that the frequency distribution of low-flow events over Lainhart Dam presented in Table 24 on Page 98 does not match well with the frequency distribution of salinity events derived from the long-term model, as shown in Tables 34- 36 on pages 138 and 139. The fact that under current (1990 to 2001) conditions, flows drop below 35 cfs for 15 days every two months (table 24) may not be comparable to the prediction that salinities will exceed 2ppt for 46 days every 6. 8 months at station 9.2, since it simply represents a three-times longer time span over which the data were aggregated (6 months vs 2 months).

Differences also occur due to the built-in response time of the model to changes in flow, which are gradual and may not reflect actual conditions that occur in the field. Finally, the model may predict that lower salinities will occur in the upper reaches of the river because relatively small amounts of tributary and groundwater inflow at the upstream end have a greater effect in the narrow channel of the river at those locations than they have in areas further downstream where the rivers widens.

Regarding the apparent differences among values based on the long-term salinity modeling effort in Tables 35, 36 and 37 with statistics based on measured flow records in Table 24. Because we have relatively good daily flow data, we can probably more accurately characterize the duration and magnitude of flow conditions much more precisely than we can characterize salinity. Not only do we have limited, incomplete and perhaps suspect salinity data to provide a basis for calibration and verification , the available data show wide ranges of variation for given flow values. The model was chosen because it provides a more or less consistent estimate of salinity and can account for some of the known sources of variability in the data (tidal cycles). However, we recognize that it may not provide a very accurate representation of conditions in the river at any particular point in time. We are assuming that these are largely randomized errors that will average out over a long period of record. We also recognize that the use of a long period of record increases the chances that we may be incorporating systematic errors that you noted in your comments, due to structural or management changes in the system that have affected the basic flow relationships, and may bias our long-term flow and salinity estimates at particular stations. We felt that this type of error was less important than being able to estimate how the system would perform under a wider range of hydrologic conditions that better represent the inter-annual patterns and cycles of flood and drought that occur in South Florida.

Page 5, 5th Paragraph: *I would suggest either working with the empirical relationships derived in Appendix D that relate flow to salinity or improving the model so that it does a better job of reproducing observed salinities. In either case, it seems like the historic salinity information is not relevant and the MFL can be set based on the current salinity regimes (e.g. it would be possible to determine what flows would be necessary to change salinity conditions at RM 9.2 such that they mimic what is currently observed at RM 10.2).*

- **District Staff's Response**: We have addressed this issue earlier in our response.

Page 5, 6th Paragraph: *Finally, I'm not sure I understand why the emphasis is on 2 ppt. If these salinities are thought to occur very rarely (e.g. the 99th percentile), then flows could theoretically be maintained at the 98th percentile without violating the MFL. However, maintaining a salinity of 1.9 at RM 9.2 would surely cause damage to the vegetation even further upstream in the River. Is the target actually to maintain average flows such that average salinity at RM 9.2 will be what is currently experienced at RM 10.2?*

District Staff's Response: **Page 5, 6th paragraph.**

- As shown in Figure 20 on page 99 for discharges from 1970 – 2001, the 2 ppt represents one point on a flow-frequency plot of overall river discharge. The actual flows from the dam will cover a range such as shown in the plot, wherein 2 ppt (35 cfs was exceeded about 70% of the time, the median flow was 65 cfs, flows of 200 cfs were exceeded 7% of the time etc. More recent data (see table 1 above) indicate that overall median (82 cfs) and high flows to the river have improved substantially, but the frequency of low flow events remains high (flows less than 35 cfs still occur 25% of the time). The intent is to shift this flow curve to a higher level, by reducing the frequency of flow events below 35 cfs to less than 1% but keeping the higher end flow events comparable to historic conditions.

Conclusion

Thank you for your insightful comments on this process. You have made us aware of many implicit assumptions that we have taken for granted by choosing to use the modeling approach and that, if left unresolved could ultimately reduce our ability to adequately protect this unique and valuable river. As you may be aware, we are in the process of upgrading this model to a 3-dimensional version and are collecting extensive synoptic flow and salinity data throughout this basin that we feel will provide the necessary information to address these issues in greater detail.

The MFL proposed in the draft document is intended to be an interim management target based on best available data. We envision the establishment of MFLs for the Loxahatchee River as an iterative process. Projects are already underway to meet the proposed flow of 35 cfs 94% of the time by 2006 and continue beyond that value to provide flows of 65 cfs 99% of the time by 2018. Studies are also underway to examine opportunities to enhance flows from other tributaries – Cypress Creek, Hobe Groves Ditch and Kitching Creek. The SFWMD is initiating studies with FDEP and other agencies to define overall restoration goals for the river that will not only include minimum flow criteria for the river but will also address needs for sustained average flows and periodic high flow periods that are needed to maintain a healthy river and floodplain and downstream estuary. It is anticipated that once the restoration goals for the river have been established in terms of desired flow and ecological conditions, that the MFL criteria will also have to be revised in order to be consistent with protection of the restored ecosystem from significant harm.